Chapter 15
Abstraction and Control of Transport Networks

Young Lee
Huawei Technologies, USA

Daniele Ceccarelli
Ericsson, Italy

ABSTRACT

Virtual network operation refers to the creation of a virtualized environment allowing operators to view the abstraction of the underlying multi-admin, multi-vendor, multi-technology networks and to operate, control and manage these multiple networks as a single virtualized network. Another dimension of virtual network operation is associated with the use of the common core transport network resources by multi-tenant service networks as a way of providing a virtualized infrastructure to flexibly offer new services and applications. The work effort investigating this problem space is known as Abstraction and Control of Transport Networks (ACTN). This chapter provides an ACTN problem description, identifies the scope of this effort, and outlines the core requirements to facilitate virtual network operation.

1. INTRODUCTION

Transport networks have a variety of mechanisms to facilitate separation of the data plane from the control plane including distributed signaling for path setup and protection, centralized path computation for planning and Traffic Engineering (TE), and a range of management and provisioning protocols to interact with network resources. These mechanisms represent key technologies for enabling flexible and dynamic networking. Dynamic networking refers to network capability that allows on-line path computation, dynamic discovery of real-time resource information and provisioning based on real-time network resource information.

Transport networks in this chapter refer to a set of different type of connection-oriented networks, primarily Connection-Oriented Circuit Switched (CO-CS) networks and Connection-Oriented Packet Switched (CO-PS) networks. This implies that at least the following transport networks are in scope of the discussion of this chapter: Layer 1 optical networks (e.g., Optical Transport Network (OTN) and Wavelength Division Multiplexing (WDM)), Multi-Protocol Label Switching – Trans-

DOI: 10.4018/978-1-4666-8371-6.ch015

port Profile (MPLS-TP), Multi-Protocol Label Switching – Traffic Engineering (MPLS-TE), as well as other emerging connection-oriented networks. One of the characteristics of these network types is the ability of dynamic provisioning and traffic engineering such that service guarantees can be fulfilled.

One of the main drivers for Software Defined Networking (SDN) is a physical separation of the network control plane from the data plane. This separation of the control plane from the data plane has been already achieved with the development of MPLS/Generalized Multi-Protocol Label Switching (GMPLS) [GMPLS] and Path Computation Element (PCE) [PCE] for TE-based transport networks. In fact, in transport networks, such separation of data and control plane was dictated at the onset due to the very different natures of the data plane (circuit switched TDM or WDM) and a packet switched control plane. The physical separation of the control plane from the data plane is a major step towards allowing operators to gain the full control for optimized network design and operation. Moreover, another advantage of SDN is its logically centralized control regime that allows a global view of the underlying network under its control. Centralized control in SDN helps improve network resource utilization with distributed network control plane capabilities. For TE-based transport network control, PCE can be deployed for centralized control for path computation purposes.

As transport networks evolve, the need to provide network abstraction has emerged as a key requirement for operators; this implies in effect the virtualization of network resources so that the network is "sliced" for different uses, applications, services, and customers each being given a different partial view of the physical underlying network and each considering that it is operating with or on a single, stand-alone and consistent network. Moreover, particular attention needs to be paid to the multi-domain case. The work effort investigating this problem space is known as Abstraction and Control of Transport Networks (ACTN). ACTN can facilitate virtual network operation via the creation of a single virtualized network. This supports operators in viewing and controlling different domains (at any dimension: applied technology, administrative zones, or vendor-specific technology islands) as if they would deal with a single virtual network.

Network virtualization, in general, refers to allowing the customers (and services/applications) to utilize a certain amount of network resources as if they own them and thus control their allocated resources in a way most optimal with higher layer or application processes. This empowerment of customer control facilitates introduction of new services and applications as the customers are permitted to create, modify, and delete their virtual network services. Customers are not necessarily limited to external entities with respect to the network providers. Customers can be an internal entity that may coordinate different domains (at any dimension: applied technologies, administrative zones, or vendor-specific technology islands). A virtual network control coordinator is a form of customer with respect to physical networks and their domain controllers. A virtual network control coordinator is a customer of domain networks in multi-domain scenarios such that the generated network abstraction is received by each domain's physical network controller.

This virtual network control coordinator can be an internal entity with respect to the operator's control domain as it facilitates virtual network operation. On the other hand, this virtual network control coordinator can be a third party entity such as bandwidth brokers that coordinate bandwidth services between networks and customers.

The granularity level of virtual control given to the customers can vary from a tunnel connecting two end-points to virtual network elements that consist of a set of virtual nodes and virtual links in a mesh network topology. More flexible, dynamic customer control capabilities are added to the traditional VPN along with a customer

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